Bay of Bengal Programme

Small-Scale Fisherfolk Communities

PEN CULTURE OF SHRIMP
IN CHILAW, SRI LANKA

BOBP/WP/60

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This paper describes trials with pen culture of tiger prawns, carried out between 1986 and 1988 in Merawela village in the Chilaw lagoon of Sri Lanka. The trials were conducted by the Bay of Bengal Programme (BOBP) in association with the Ministry of Fisheries, Government of Sri Lanka, and the local Social Development Organization, an agency established by the Ministry of Fisheries to encourage development schemes in fishing villages.

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This document is a working paper and has not been cleared by the Government concerned or the FAO.

CONTENTS

1. BACKGROUND

Penaeid prawn culture in pens was first tried out by BOBP in Killai, India, in 1982. At that time there were no known reports of such a production system being tried out anywhere else. It was believed that if successful it could become a small-scale, part-time, activity possibly household-based. It would require much less initial capital investment than conventional pond-based culture and would be less risky. Also, suitable land for pond construction is rare or often not available to small-scale fisherfolk communities; by contrast, the shallow coastal lagoons of India and Sri Lanka are considered suitable for pen construction.

The original trials in Killai focused on the culture of *P. indicus;* seeds were available from the local backwaters. Technical feasibility was demonstrated, but profitability remained elusive, mainly because of the low prices fetched by the small white shrimps produced (BOBP/WP/49).

Similar problems were faced during three successive trials in Negombo Lagoon, Sri Lanka, 1984-1985 carried out in collaboration with the Coastal Aquaculture Research Station in Pitipana: yields of white prawns were considerably lower than even those obtained at Killai (average 160 kg/ha/cycle versus 600 kg/ha/cycle).

By 1986 a concerted effort was considered necessary to make the system profitable failing which the trials would be terminated. The tiger prawn *Penaeus monodon* (which can be cultured to large size) was considered a key to profitability; a high-quality formulated feed was another “must.”

From the experience gained in Killai and in Negombo it appeared that some of the problems were extremely site-specific. The Sri Lankan trials were shifted from Negombo to Merawela in the Chilaw lagoon. The proximity of the Pambala Brackishwater Fish Breeding and Experimental Station would facilitate technical monitoring at Merawela. The culture trials in Merawela started end-1986. Similar trials undertaken in Killai failed totally, hence that sub project was discontinued in December 1987.

Only the trials undertaken in Merawela are reported and evaluated herein. The immediate objective of the trials was an “assessment of the technical, economic and social feasibility of prawn culture in pens in coastal lagoons in Sri Lanka on a small household basis.”

Merewala is not a fishing village. The two major income generating activities in the village are lime manufacture and arrack distillation. Lagoon fishing has come into being as an ancillary activity because of the proximity of the lagoon. Merawela is a dynamic village with a high self-help attitude. It easily unites around common objectives. It is not a poor village. However, because lime manufacture is associated with low caste, and arrack distillation is socially condemned, the villagers, particularly the young, are eager to take up other income-generating activities. Shrimp culture has generated a lot of interest, and several ponds have been dug. However, most of these have been dug illegally in acid soils in a mangrove reserve and are unusable.

2. ORGANIZATIONAL SET-UP

Three parties were involved in the trials: the Ministry of Fisheries, the Bay of Bengal Programme and the local Social Development Organization (SDO). The SDOs are set up by the Ministry of Fisheries in fishing villages as a channel for various development schemes; they are also supposed to take up development work on their own.

The trials were conducted at two Sites a few hundred meters apart. Site 1 was accessible by road. Work there started in September 1986. Site 2 was just opposite the village and was accessible only by boat. It was operational from March 1988. Both sites were staffed by three village youths each. Those at Site 1 were recruited directly by the Officer-in Charge (OIC) of the Pambala station.

The trials at the second site were supervised by the SDO which had nominated some of its members for this purpose. The cooperation between the SDO and BOBP was governed by a Letter of Understanding. It stipulated that the SDO would reimburse feed and seed costs and the salaries of the three youths from the sales proceeds of culture trials.

BOBP played a supporting role in the purchase and supply of major inputs such as feed and seed. Work programmes were decided in consultation with the SOO and the Pambala station staff during field visits by BOBP staff.

3. TECHNICAL ASPECTS

3.1 The Sites

Figure 1 shows the location of the two sites. Site 1 was located at the mouth of a channel linking the lagoon with the sea on the side of the village. Though the tidal amplitude never exceeded 50 cm, currents could be very swift. The bottom was mostly sandy. The water depth was around 1 m. An old navigation channel, almost totally silted, ran through the site and was about 0.5m deeper than its environs. The lagoon-sea navigation channel lies beyond the pens, closer to the opposite shore. Two pens were constructed here. Pen 1 was 25m x 100m Pen 2 alongside was 30m x 6Gm. Both pens stood roughly parallel to the shore. The original intention was to construct two 0.25 ha pens sharing a common 100m long wall but this layout was modified to avoid interference with boating. Pen 2 tended to be slightly deeper than Pen 1.

Site 2 was located in a channel between an island and the mainland, slightly south and west of site 1. It was separated from the village by the lagoon-sea channel. The water depth was similar. Currents tended to be less swift. The bottom was a thin layer of rich organic mud resting on fairly compact silt. Two pens were constructed on Site 2. Pen 1 was rectangular, 90m x 25m. Pen 2 was a 9Gm long trapezium. The short sides were 20m and 25m respectively. Allowance was made for passage of outrigger canoes on both sides of the pens.

3.2 Pen Construction.

3.2.1 Site 1

These pens were constructed in September-October 1986 according to guidelines developed earlier in Killai, India. Single-knot webbing with a stretched mesh size of 12mm made out of 0.5mm HDPE twine was used. The twine had been imported, and the webbing made at a local state owned net factory. The twine was of irregular quality, and the HDPE was found to be rather stiff. This caused problems during the manufacture of webbing. The quality of the webbing therefore was not too good. HOPE was used because in India it had proved more resistant than nylon to crab cuts and was cheaper as well.

The webbing was rigged with a foot rope and a lighter head rope. A loop in the foot rope was made at regular intervals to secure the net panels to the poles. The bottom part of the webbing was dug in at least 30-50cm deep. Those parts of the pen walls which were placed across the major currents were later taken up and weighed down with a chain. This procedure solved the prbblems posed by wall lifting and subsequent escape of prawns from the pens.

Originally, bamboo poles were used to support the whole structure. They were hammered into the mud from a movable platform. Only full-grown bamboos were used, as young ones rotted very fast. Even so they had to be replaced after less than a year. Later, bamboo was replaced by tanmenna poles *(Mischodon zeylanicus,* Euphorbiaceae). Because these were not straight, they were placed in a hole drilled by a pump-activated water jet. Tanmenna poles last longer in saline water than bamboo poles and are less prone to fouling.

The top part of the nets was stretched and tied to horizontal reepers made out of split bamboo or mangrove sticks.

3.2.2 Site 2

This farm consisted also of two pens. The pen material was extruded HDPE netting of 6 mm bar length. The material was semi-rigid and came in units 30m long and im high.

Before installation, two pieces of pen material were sewn together with 2 or 3 mm nylon rope. The tanmenna poles used were placed 3m apart, except in the short sides of the pen, where they were 2m apart. Poles and netting were installed with a water jet activated by a pumii with a motor placed on an outrigger canoe. The netting was buried 30-50 cm deep into the mud. The average water depth was im which left a 50 cm free board.

3.3 Nursery Rearing

Hatchery produced post larvae (usually PL-20 at delivery) were too small to be stocked directly into the pens and needed to be nursed till they reached about 1.5g weight.

The nursery-rearing protocol in Merawela made use of a series of happas increasing in mesh size and total area. Happas are cage-like structures made of a woven material similar to mosquito nets. The mesh sizes are expressed as number of meshes per inch; thus a 30P material has 30 meshes per inch.

After acclimatization, the post larvae were stocked in 30P happas where they were fed egg custard six times a day. The custard was prepared by steaming a homogeneous mixture of roughly equal volumes of milk powder and raw egg. It was then cooled and extruded through a fine mesh cloth before being fed to the post-larvae. One to three weeks later the post-larvae were transferred to 16P happas. Their diet was gradually modified by introducing crumbled pellets and eventually minced clam meat and by reducing the amount of egg custard. After 2-3 weeks the juveniles were fed exclusively on the crumbled commercial ration used for grow-out in pens. The quantities fed were adjusted according to the consumption observed.

To reduce cannibalism and accelerate growth, the juveniles in the 16P happas were graded once a week, and the larger ones (about 0.5g) stocked in 8P happas. Juveniles in the 8P happas were also regularly graded and stocked into the pens as they reached approximately 1.5g. No attempts were made to determine optimum stocking densities in the happas. The sub-project bought four happas of each type, 12 in all. This proved adequate to nurse 30,000 PL-20s to the stocking size in 9-12 weeks. Under these circumstances the maximum densities observed were 650, 400 and 150 numbers per square meter in 30P, 16P and 8P happas respectively.

Grading was done by first crowding all the juveniles to one side of the happas, then transferring the bigger ones to the next happa or to the pens. The happas were placed along the pens, well stretched and with their base clear from the mud to avoid accumulation of uneaten food and faeces. The small meshes clogged rapidly and had to be kept clean by regular brushing.

3.4 GROW OUT

3.4.1 Pen maintenance

During the operation of the pens, the following problems were experienced and required remedial action.

- lifting of the pen walls;
- holes in the nets;
- fouling of the nets;
- rotting of the supporting poles; and
- fouling of these poles.

Lifting of the pen walls was due to the scouring and pulling action of tidal water currents. It occurred towards the end of the first trial in Site 1, and caused near-total loss of a promising crop. The places affected were those across the currents and where the water was the deepest. Before the second trial, the nets were taken up loaded with a chain before placing them back. The distance between the two poles was also reduced by half. Following this incident the depth to which the pen wall was buried was regularly checked and action taken if necessary. No lifting of the pen walls was ever noticed at Site 2. Probably because the material was not very flexible and was tied to poles over its whole height and not just at the bottom and at the top. Holes in the nets were a recurring problem at Site 1. Possible reasons: crab cuts, drifting objects and material failure. Under water checking for holes in the nets became a daily routine. Small holes were repaired by mending the nets. Bigger holes were covered by a piece of spare material. In doing so, care had to be taken to avoid the formation of pockets in which trapped shrimps would die. Damage due to the impact of drifting objects was reduced by placing a barrier of branches and nets across the major currents outside the pens. Fishing for crabs was actively carried out both in the pens and around it. Material failure was due to bad-quality twine (it would sometimes unravel) and to problems experienced during net-making. Material failure increased towards the end of the second year, probably due to the combined action of sea water and sun light. No such problems were experienced at Site 2.

Fouling of the nets was hardly unexpected. All kinds of organisms would settle on them, but most of them would soon die off because of salinity variations. The nets were cleaned by brushing them, eventually following a prior application of lime. It was, however, not possible to keep the nets clean of fouling.

Poles occasionally needed to be replaced. The bamboo poles in particular would get quickly water-logged and attacked by wood borers. They lasted a year at the most. Tanmenna poles seemed more durable. The bamboo poles would break off shortly above the substrate, leaving a stump which could damage the nets. The stumps therefore needed to be removed before a new pole was placed. Tying the foot rope of Site 1 pens to the poles made this operation cumbersome.

Fouling on the poles was a problem only when caused by barnacles. Oyster settling was never noticed, though some do grow in the lagoon. Mussel spat would die and fall off the poles before it grew too big and damaged the nets. Barnacles would die off too at the first salinity drop, but because they stuck to the poles they had to be removed to avoid damage to the nets rubbing against it.

3.4.2 Pest removal

Pests either competed for food and space with the stocked prawns or preyed on them. Pests formed the single most important impediment to succesful prawn culture in pens. They entered the pens either in their early life stages when they were small enough to pass through the netting, or by passing above or under it (crabs and eels). Occasionally pests entered the pens, through cuts in the netting material.

Techniques tried to control pest populations in the pens were varied: traps, dragnets, cast nets, bush piles and other fish-attracting devices such as PVC pipes and old tyres.

Dragnets were used to 'clean' the pens before stocking. They were dragged along the pens, with their edges by the penwalls and their bottom on the mud surface. Pests were thus crowded on one side of the pen and were easily removed by cast nets or scoop nets. Some pests however, managed to escape either by burying themselves, jumping over the net or passing between the pen wall and the hedge of the drag net. Dragnetting was therefore usually repeated three times or until hardly anything more was caught. Different types of traps were tried. The most efficient one is cylinder shaped with a segment cut out of it with a small opening above the bottom, close to the center. Used with a leader, it was extremely efficient in catching small *Metapenaeids* sp. and the cultured stock. Because of their efficiency, they needed to be checked regularly and their content emptied lest the caught *P. monodon* died off.

Bush piles, PVC pipes and old tyres were also introduced into the pens. These provided shelter and rest places for various fish. Pipes and tyres attracted eels and morays as well as groupers. The fish were caught by lifting these objects out of the water while keeping a scoopnet under them. Bush piles were often used in addition to drag nets. When disturbed, fish sought refuge in the bush pile, which was then surrounded by a drag net. The bush pile was then removed, and the fish caught.

3.4.3 Feeding

Feeding was done four times between sunset and sun rise. The feed was placed on feeding trays, 12 in each pen. The trays were made out of a wooden frame (about 50 cm x 50 cm) covered with mosquito netting, weighted down with a stone and suspended about 30 cm above the bottom. The feed used was an experimental commercial ration developed by a local feed mill. The feed formula was suggested by BOBP, and further developed by the nutritionist of the feed mill.

The feeding trays were regularly checked for left overs one hour after placing the pellets, and the quantities fed were adjusted according to the observed consumption.

3.4.4 Harvesting

Harvesting was usually started at night or early morning when the prawns were most active. It was done with traps or castnets, or both.

The traps were the same as those used for pest removal, though sometimes the small mesh netting was replaced by bigger mesh netting. This was to avoid an excessively large amount of undersized

P. monodon and *Metapenaeids* sp. being caught, when the aim was to partially harvest the bigger prawns and to release the small ones unharmed.

Cast netting was most effective at night and early morning and in the deeper parts of the pens. During cast netting, prawns escaped to the sides of the pens, only to get caught in the traps.

If partial harvesting was carried out, the larger prawns caught at night were kept alive in a cage, pending sorting during the day. The target size was an average weight of 26 g. Undersized prawns were then released back to the pens. Commercial-sized prawns were kept alive till transport to the buyer. In the case of a complete harvest, the prawns were kept in ice in a styrofoam box till purchase.

3.4.5 Data collection

The youths employed at Site 1 made daily measurements at 8 a.m of the salinity and the temperature of the water both at the surface and about 30 cm above the bottom, a few metres from the shore. At both sites daily records were kept of the amount of feed. Once a week growth samples were taken from the pens and the happas by staff of the Pambala Brackishwater Fish Breeding and Experimental Station. From each pen 100 prawns were caught by cast netting, their length and weight measured, and released back to the pen. Because of their small size the prawns in the happas were not measured and weighed individually. For each happa the average prawn weight was estimated by weighing 50 juveniles in small net bag, subtracting the weight of the net and dividing by 50.

The data was recorded on specially designed forms. Log books for recording daily work were kept at both pen sites. The data and the work done were summarized on a weekly basis on batch, history record and pen history record forms.

3.4.6 Management strategies

Management of the pens may be conceived in two different ways. One way is to stock the pens within a short period of time, harvest prawns when most have reached the desired size, clean the pens and get them ready for the next stocking. Another way is to combine staggered stocking with partial harvesting of the large prawns.

For a target group of small-scale fisherfolk communities it was believed that staggered stocking and harvesting would show the following advantages

- It would integrate well with nursery rearing practices, in which much time may elapse between growth to stocking size of the first batch of juveniles and the last batch;
- it would allow a more intensive use of the pens, which otherwise might remain empty between two trials;
- cash flow would be easier to manage for people accustomed to a regular income.

Examples of crustacean culture using this system of management are found in commercial freshwater prawn farming (New and Singholka, 1985*) and in traditional Indonesian aquaculture. Earlier, Ojeda et al (1980**) had shown that staggered stocking of *Penaeus stylirostris* resulted in higher mean survival rates and higher yields than expected.

3.5 Cost of pens

The investment required for constructing a 0.5 ha farm consisting of two 0.25 ha pens and for buying necessary materials is estimated at SL Rs. 90,000 (US$ 3,000). This figure does not

New, MB. and S. Singholka, 1985. Freshwater prawn farming. A manual for the culture of Macrobrachium rosenbergii, FAQ Fish. Technical Pap., (225) Rev. 1 118 p.

Ojeda, J.U., DV. Aldrich and K. Strawn, 1980. Staggered stocking of Penaeus stylirostris in brackishwater ponds receiving power plant cooling water. Proc. World Maricult Soc. 11 23-29.

cover possible duties for the import of HDPE webbing. Investment requirements are detailed in the table below.

	Unit	*Quantity*	*Unit price (S. Rs.)*	*Cost (S.Rs)*	*Depreciation in years and yearly value*	
Pen Construction						
HDPE	roll	32	1500	42000	4	12000
Nylon net	kg	3	600	1800	2	900
Poles		170	18	2975	2	1488
Ropes	spools	20	120	2400	2	1200
Reepers	bundles	13	50	650	2	2500
Labour	man days	50	50	2500	1	2500
Kerosene	gallons	15	35	525	1	525
Sub-Total				58850		18938
Nursery 30 P		4	1500	6000	4	1500
16P		4	1550	6200	4	1550
8 P		4	2680	10720	4	2680
Others				500	*4*	125
Sub-Total				23420		5855
Gear for harvesting and pest control						
Cash net		4	900	3600	2	1800
Dragnet		1	2000	2000	2	1000
Traps		4	500	2000	2	1000
Scoopnets		2	50	100	2	50
Rigifoam box		2	50	100	2	50
Buckets		2	50	100	2	50
Sub-Total				7900		3950
Grand total				90170		28743

4. RESULTS

4.1 Temperature and salinity variations

Approximately two years of data on water temperature and salinity were collected during the trials. These data are summarized and presented in graphs in Appendix 2. There has never been any evidence of stratification at the pen site. Differences in measurement for the bottom and the surface were non-existent or very small. That it was so could be anticipated in view of the shallowness and the narrowness of the channel linking the lagoon proper with the sea. Water temperature has never been a limiting factor during the trials.

The lowest (25-26°C) and highest (30-31°C) water temperatures were recorded in January/February and March/April respectively. Most of the year the readings were between 27 and 29°C.

Water salinity has been far more variable than water temperature, being influenced by fresh water draining into the lagoon and by the tidal exchange of water with the sea. Heavy rains in the catchment area caused the saline water to be flushed out, causing a drop in salinity, eventually to zero levels. Prolonged periods of drought resulted in salinity stabilizing at seawater level (33-35 ppt). During such periods of heavy rainfall or prolonged drought, the daily salinity variations remained minimal or nil. However, following moderate rainfall, the daily variations may be considerable, up to 10 ppt in 3 hours, and reflect the tidal conditions.

Meteorological data from 1951 to 1980 show that on an average while there is some rainfall the year-round, there are two major rainy seasons, during April-May and October-November, associated with the onset of the south-west and north-east monsoons respectively. The latter rainy season is more important. However, the variation from year to year is very big. This was clearly demonstrated in 1988. The rainfall and consequently the salinity variation were unpredictable: this seriously disturbed planned culture operations (Appendix 3).

4.2 Nursery rearing

Nursery rearing lasted 2-3 months. The survival rate from PL-20 to 1-2 g juveniles varied between 44% and 83%. Several factors have affected the results, the major ones being

- the water salinity and its variations
- the experience of the staff; and
- the quality of each brood of PLs.

Salinity has varied widely during the trials and this has at times severely hampered nursery rearing. For instance a sudden drop to 0 ppt caused heavy mortality in batch No.4. This however was limited to the first few days following the salinity drop. Subsequently, the post larvae adapted to the low salinity and mortality was negligible until they were stocked. Final survival was 50%. Because of the low salinity and the initial problems experienced with batch No.4, batch No.5 was nursed in ponds at the Pambala station. The juveniles produced were used for growout experiments at the station. Batch No.5 is of no further relevance to the present discussion.

Juveniles of broods 7, 8 and 9 were used at both sites. Brood 7 was nursed at Site 1 while the juveniles of broods 8 and 9 intended for stocking at Site 2 were partly nursed there by the SDO team.

At delivery the post larvae of batch No.8 seemed weak and were not very active. After being nursed in the 30 P and in the 16 P happas, about half of the juveniles were transferred to 8 P happas at Site 2; the remaining were nursed at Site 1. Likewise, half of the juveniles of batch No.9 were transferred to Site 2, after having been nursed in 30 P happas at Site 1, for further nursery rearing by the SDO team.

The duration of the nursery rearing period varied between 52 and 100 days. The longer rearing periods probably reflect slower growth rates at the higher stocking densities used and unfavourable salinity regimes. Two to five weeks elapsed between the initiation and the completion of stocking.

The variable production costs of stockable size juveniles were monitored. Because of circumstances (salinity problems for batches 4 and 5; training aspects for batches 1, 2, 8 and 9) only the data from batches 3, 6 and 7 are worth considering. Feed costs amounted to Rs.4,500, Rs.1,200 and Rs.2,750 respectively. Egg custard accounted for about 10% of the cost. At the current purchase cost of Rs.65 for 100 post-larvae, the variable production cost per juvenile is estimated at Ret.

A summary record of the nursery rearing results is given in Appendix 4.

4.3 GROW OUT

4.3.1 Production

Four trials were conducted. As a rule the income generated, mostly through the sale of tiger prawns, was not sufficient to cover even the costs of feed and seed.

Trial 1 was conducted in one pen only and lasted 3 months. The stocking density adopted was 20,000 juveniles per hectare. During this trial the salinity remained fairly constant and high (30-35 ppt). The harvest seemed promising till about two weeks before the planned date when the prawns disappeared from the pen. This was generally attributed to the escape of the stock following lifting of the pen walls. However, since there was no evidence of foul play and sjnce the prawns had grown to a large size, the results were considered positive. During the second trial both pens were stocked, pen 1 at the same density as previously, pen 2 at double that density (40,000/ha). The results from pen 2 were much better, both in terms of recovery percentage (64% vs 45%) and average size (28g vs 26g), in spite of the higher stocking density. The production achieved in pen 2 (720 kg/ha) indicated that under a certain set of conditions a good harvest of prawns from pens was possible. The feed conversion ratioof 2.4: 1 (feed to prawn) was deemed very satisfactory in a pen environment amid competitors and predators, and indicative of a good quality feed. The third trial started early September, just before the onset of the north east monsoon, which was very active that year. It rained a great deal and the salinity plummeted to zero very soon. Result: a massive mortality, first of the less euryhaline fish and crustaceans present in the pens (siganids, carrangids, groupers, white prawns etc.), then of the tiger prawns. This prompted a decision to harvest whatever was left in the pens, though growth had been poor and the average size of the prawns still low. What caused the high mortality? The drop in salinity was certainly detrimental to growth and survival, but an additional factor was probably that the sudden heavy rains flooded agricultural land and flushed various drainage canals, thus leading to very poor water quality.

Out of this experience several points became clear

- Culture operations needed to be planned in such a way that the pens were empty before the onset of the North East monsoon;
- On the basis of the past year's experience, the pens were thought to be usable approximately from January through September.

The fourth trial was to be conducted in four pens at two sites. Experience gained the previous year and the anticipated advantages for small-scale operators (see above), dictated a decision to stagger stocking and harvesting. As per plan, stocking was to be carried out on a weekly basis from January at Site 1 and from April at Site 2 till the end of July. Harvesting was to start in May and terminate September or early October. The target was to stock as many juveniles as would have been stocked totally at a density of 40,000/ha in three "batch" cycles at Site 1 and two "batch" cycles at Site 2.

Stocking ran behind schedule and was completed only late August. Partial harvesting started on schedule but because of slow growth, was not completed till December when not even all the prawns had reached the target minimum size of 23g. The result of this fourth trial was poor in all four pens. The reasons are manifold

- Vandalism. Pens 1 and 2 at Site 1 and pen 1 at Site 2 were extensively damaged in March and October 1988 respectively. The damage was caused intentionally by outsiders. A very substantial portion of the stock was lost.
- Salinity variations. The period June to October 1988 has been one of the rainiest in recorded meteorological history for the region (beginning 1911). Result: repeated and substantial salinity variations which certainly took their toll.
- Pests. It proved very difficult to control competitors and predators in the pens. Several methods were tried out, but there is no doubt that large populations, particularly of catfish and pearl spots, remained in the pens and competed for food with prawns. Interestingly, rabbit fish were the dominant pest when the salinity was high and relatively stable. Both catfish and the pearl spot reproduce in the pens.
- Quality of the netting material. By mid-1988, the HDPE nets used at Site 1 had deteriorated to a great extent, calling for frequent checking and repairs.
- Disease. Black spots and soft shells were noticed at Site 2 when the salinity was low. About 20% of the prawns were affected. Incidence of disease decreased rapidly when the salinity increased.

A summary of the production results is found in Appendix 5. The composition of by-catch from trials 2 and 4 is given in Appendix 6.

In the case of pen 1 trial 4, it seems possible to attribute the fitted growth curves to broods 4, 6 and 8 respectively, taking into account that the sizes at stocking (approx. 40 mm) and the dates of stocking are known for each brood. Batch 7 seems to be totally unaccounted for while batch 9 is probably denoted by the series of peaks at 50 - 60 mm observed in September.

5. RELATIONS WITH THE SDO

The trials described here could not be conducted in isolation from external human factors - as would have been desirable for a new and yet unproven technology. Merawela village, more particularly the fishermen's association, had to be involved in the subproject though this introduced additional management complications for the following reasons –

- Pens are relatively fragile and are easily damaged. To get meaningful results the subproject needs sustained goodwill from the villagers;
- The pens occupied an area of the lagoon close to the village. They inevitably hindered navigation and excluded fishing operations on a traditional fishing ground;
- Village youths were employed in the subproject;
- Since the trials lasted at least 3-4 months each, close supervision of the staff became problematic and more reliance had to be placed on sustained staff motivation.

At the subproject's inception village participation was limited to permitting occupation of sites selected by the Ministry of Fisheries and BOBP. The SDO refused, and ultimately another site was agreed on.

After the first trial was concluded it became clear that there were a lot of misunderstandings as to the nature of the subproject and that the relations between the youths employed and the SDO were tense at the best. In an effort to correct the situation BOBP started to attend monthly meetings of the SDO, often together with an officer from the Pambala Station. As a fillip and an incentive to reliable data collection, it was suggested that the village youth employees get a bonus and the SDO a gift to be used for the whole village. Income from the second trial could finance the bonus and the gift. This offer was intended to create a sense of collective responsibility towards the security of the pens following accusations of vandalism and poaching.

Participation in the monthly SDO meetings was a fruitful exercise. The SDO was kept briefed about the subproject and the ongoing trials and urged to take a more active interest in the actual running of the pens. At these meetings two major issues were brought forward. The first one was the behaviour of the three youths employed in the subproject towards outsiders, which the SDO disapproved of. The SDO spurned an offer to replace them by people of its choice and asked for two pens of its own. This request was eventually complied with, and these two pens were constructed in March 1988.

The second issue related to statements allegedly made by investigators of an "action-research" study on people's participation. The study was commissioned by BOBP and implemented by a local consultant. It was aimed at elaborating a village development plan, through discussions and consensus among all the villagers. The most controversial statement, attributed rightly or wrongly to the consultant and his team, was that for BOBP the lagoon belonged to everyone – regardless of whether or not a person obtained a living from it – and that everyone should be allowed to put up pens should they prove profitable. This statement generated considerable suspicion about the BOBP's intentions towards the fishermen.

Towards the end of the subproject, the BOBP's intentions concerning the village development plan were occasionally raised by the SDO. It is possible to say from hindsight that conducting the action research study on people's participation in parallel with the technical subproject raised the expectations of villagers unrealistically. It also confused and complicated relations with the SDO.

Nevertheless, BOBP's relations with the SDO and with the village were good. It is impossible to attribute the acts of poaching and vandalism at the pens to hostility towards the subproject as such. They probably represent risks which pen operators would have to confront and which are now faced by all prawn farms in the same area.

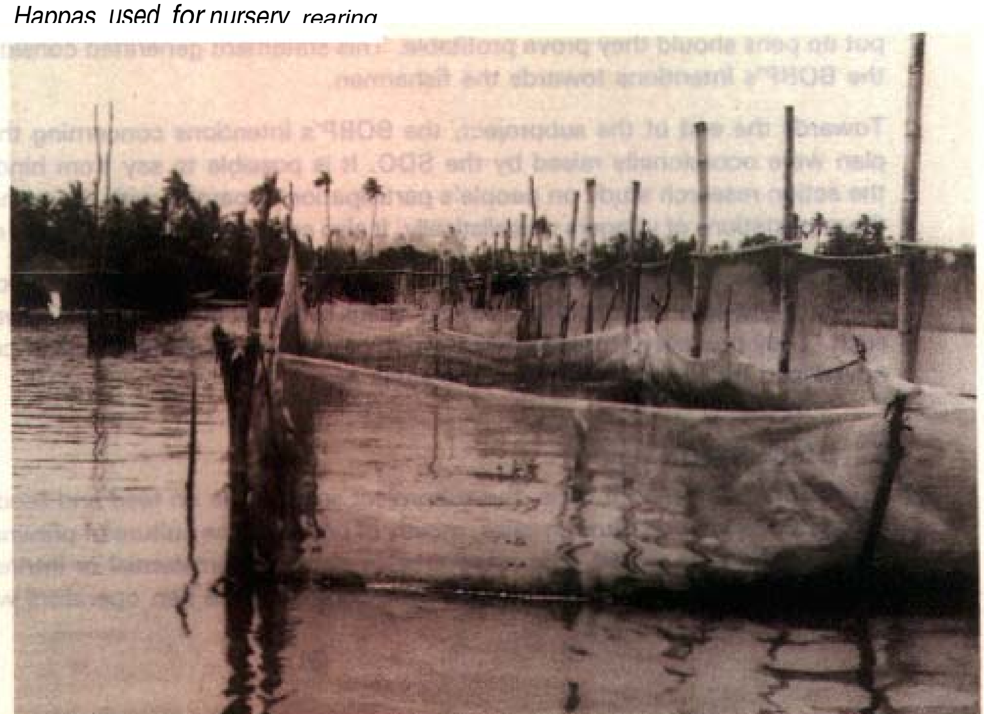
6. DISCUSSION

During the two years of trials, the subproject spent more on feed and seed alone than what was generated as income through sales, mostly of prawns. The culture of prawns in pens did not prove viable at the sites tested. The reasons were either circumstantial or intrinsic to the technology. Circumstantial reasons mostly beyond the control of the pen operators were

PEN CULTURE AT CHILAW – GLIMPSES

View of the pens from Site 1, showing also one of the traps used.

Happas used for nursery rearing



Grading of juveniles for pen stocking.

Pen construction with Netlon pen walls

Feeding tray is lowered into a pen.

- Vandalism and poaching;
- Salinity variations in the lagoon. In view of the variability of the monsoonal climate, average climatic data were not useful for planning culture operations. The risks from unseasonal or exceptionally strong rains are too high.

Intrinsic reasons directly related to the technology or to the management of the pens, were

- Difficulties in controlling pest populations in the pens. Drag-netting is the most efficient method to remove unwanted fish and crustaceans, but it can be used only between culture cycles. When the pens are stocked, other less efficient methods which do not disturb the prawns excessively have to be used. In the case of a staggered stocking and harvesting schedule, this may lead to an excessive build up of pest populations;
- The high risk of the stock escaping. Tiger prawns do not occupy the entire area of the pens except when feeding. They tend to go continuously around the pen walls. This behaviour increases the risks of prawns finding a hole and escaping through it. Holes may result from crab cuts, from the impact of drifting objects, from wear and tear, from human action deliberate or accidental.
- The suitability of pen wall materials. The size of the prawns during stocking and their behaviour poses stringent requirements as to the quality of the pen material. This matter has not been satisfactorily resolved. The extruded HDPE material used at site 2 seems to be the best although it is costly, but little is known about its lifespan.

These factors jeopardize the viability of prawn culture in the sites tested so far. Besides, there is circumstantial evidence, both from Merawela and from previous trials in India and Sri Lanka, that most shallow coastal lagoons might not actually be suitable for prawn culture in pens as conceived by the subproject.

Of all the trials conducted by BOBP, the best results were obtained in Site 1 at Merawela. The Site 1 bottom is fairly sandy and compact. All the other sites had mud with a high organic content as its bottom. Sandy bottoms are associated with stronger water currents, an important factor in maintaining a suitable rearing environment. Black spots and soft shells were noticed only at Site 2 in Merawela, during a period of fresh water dominance. The bottom mud there is anoxic and smells of hydrogen sulphide, When under stress, tiger prawns tend to bury themselves. During periods of low or zero salinity this behaviour might have exposed them to toxic hydrogen sulphide. This would mean that other factors apart, technically the best places for pens are in channels linking the lagoons with the sea and in estuaries, not in the lagoons proper.

7. RECOMMENDATiONS

The immediate objective of the subproject was an "assessment of the technical, economic and social feasibility of prawn culture in pens in coastal lagoons in Sri Lanka on a household basis". On the basis of results obtained during two years it appears that prawn culture in pens in coastal lagoons of Sri Lanka is not economically feasible. There is therefore no ground on which extension of the technology to any target group could be justified, even though the youth employed for the trials clearly demonstrated that they were able to manage the technical aspects of pen culture.

The concept of pen culture remains interesting however, and can be taken up again in lagoons or estuaries where the salinity fluctuations are sufficiently predictable to allow planning of culture operations. In fact, in Chachoengsao province, Thailand, cage culture of tiger prawn is catching on quickly. Only one culture cycle of about four months is carried out per year during the dry season. The cages are placed in estuaries where the water is several meters deep. The trials started in 1987, and by 1988, 300 to 500 cages were being operated. (Information provided by the Chief of Chachoengsao Fisheries Station, Mr Sombhong Suwannatod).

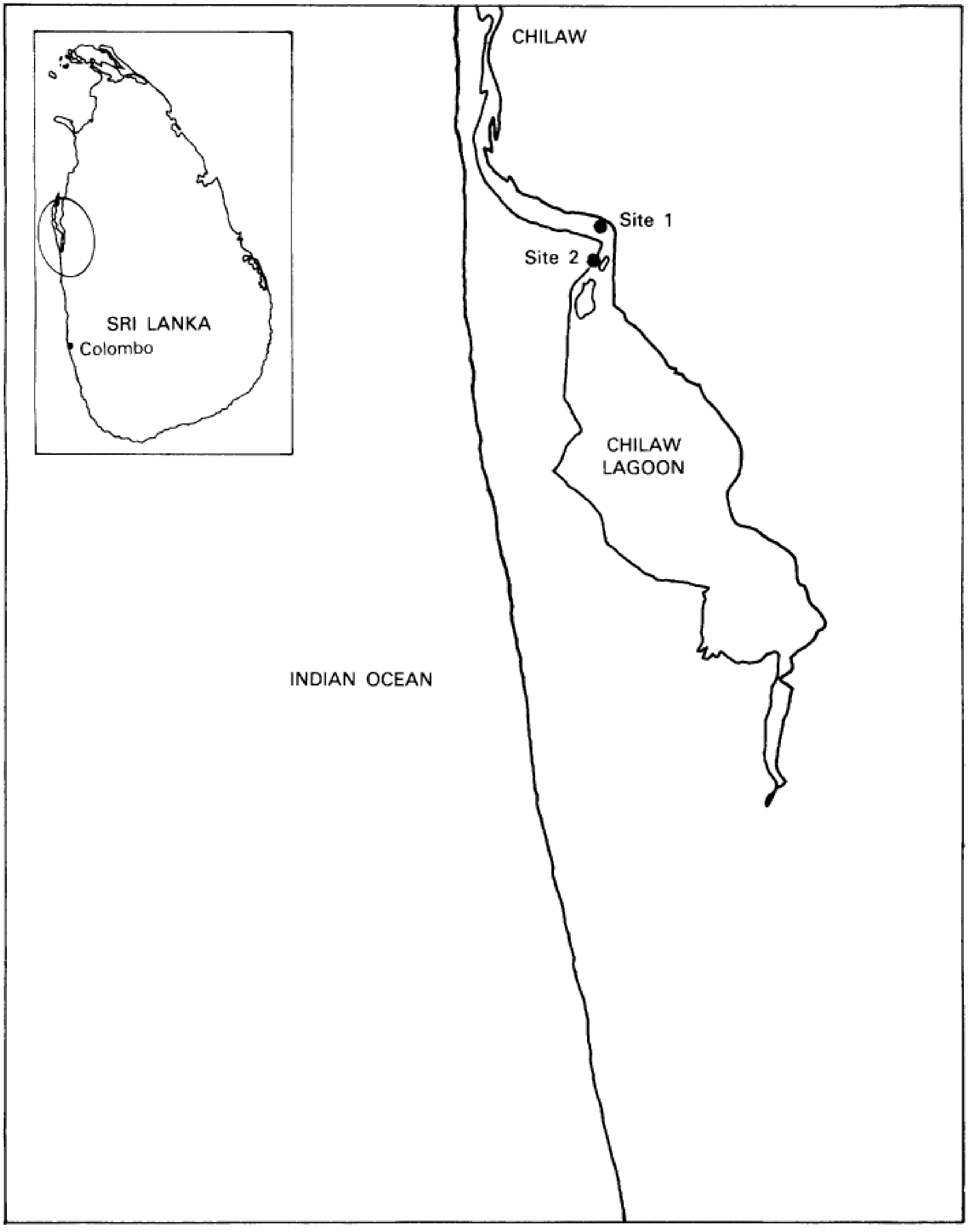
Several possibilities exist for further research and trials which might lead eventually to a commercially attractive technology for prawn culture in pens. Some of these could be

- Polyculture of prawns and fish, or alternated culture of prawns and fish. Fish would be the major crop, prawns would be incidental. It is known that fish culture in pens is possible. Such a technology would probably be less risky technically. It was not tried out by BOBP mainly because local fish species which could be cultured in pens do not fetch a good price;
- Smaller pens managed more intensively.

Smaller pens, 50-100 m^2 in area might be easier to manage, and entail less financial risk but might be costlier per unit area. It would be necessary to stock at higher densities, and maybe to reduce feed costs by increasing the natural productivity – through bush piles, for example.

Appendix 1

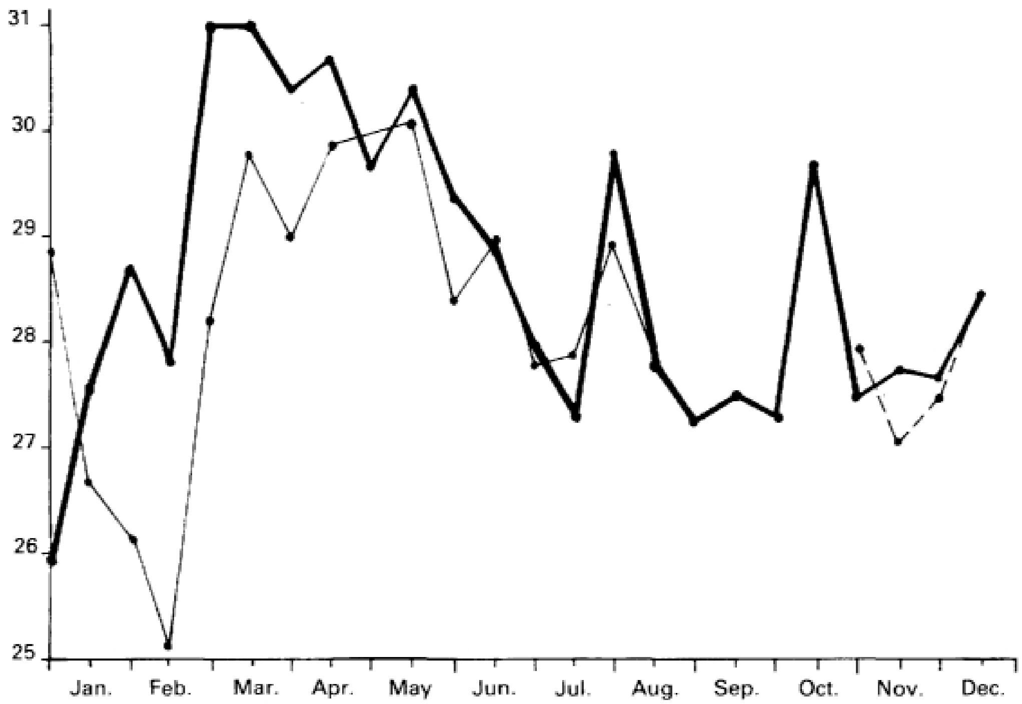
PROJECT LOCATION

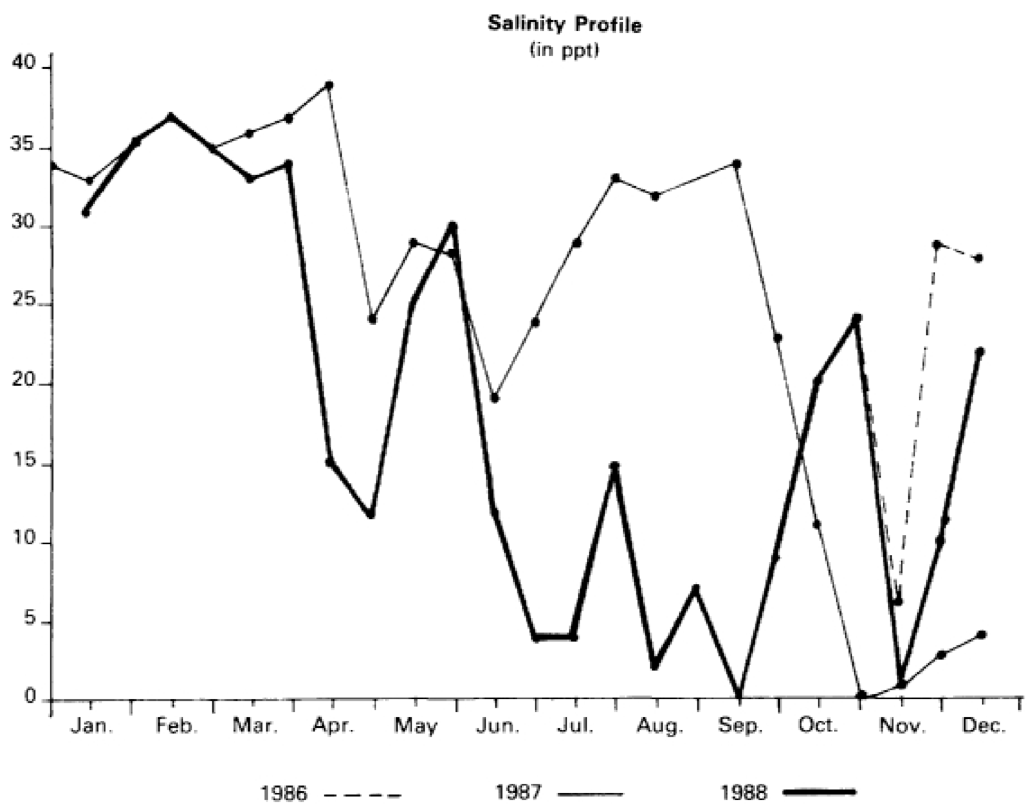


Appendix 2

TEMPERATURE AND SALINITY VARIATIONS AT SITE 1

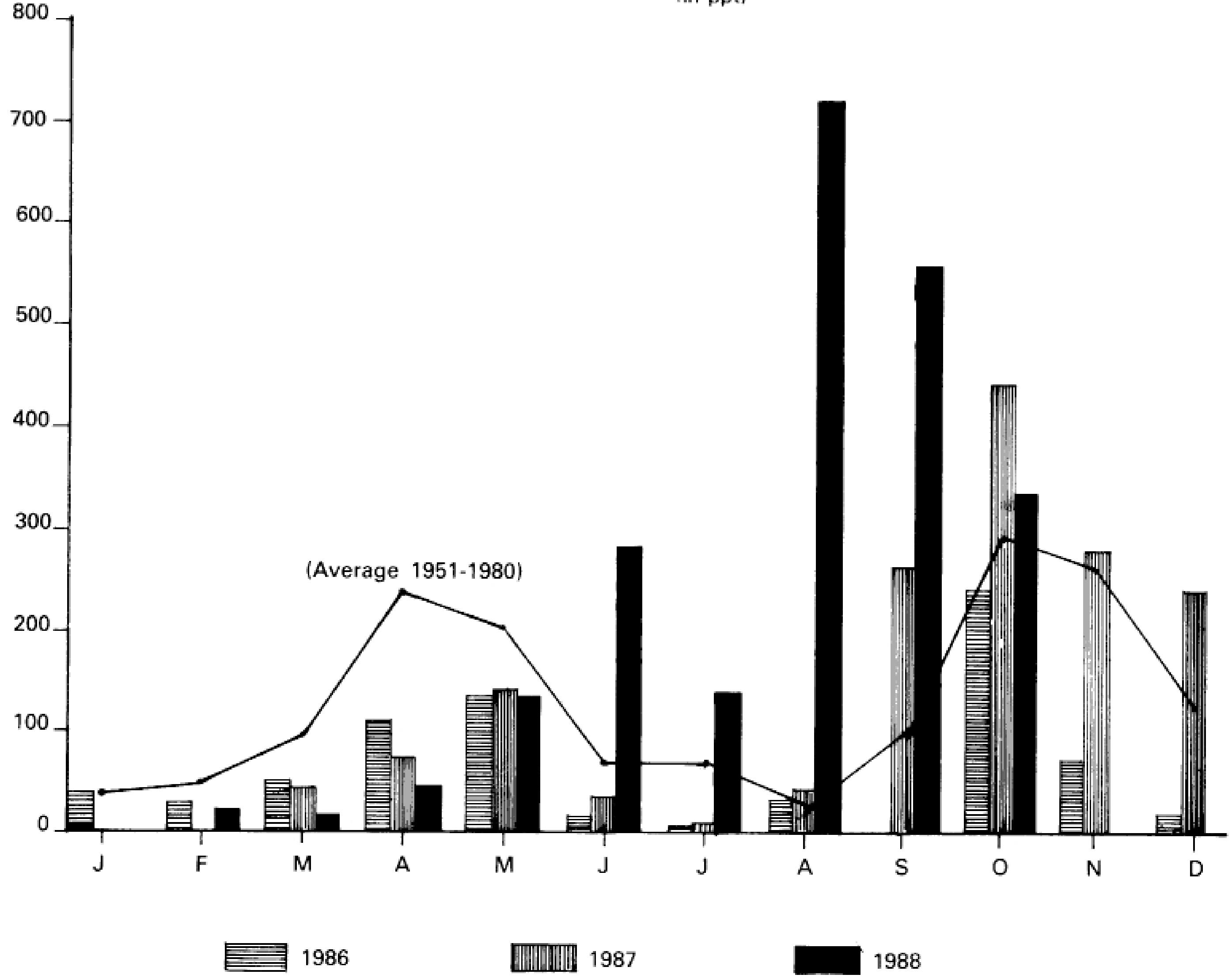
Temperature Profile
(in degrees celsius)





Appendix 3

RAINFALL PATTERN IN CHILAW
(in ppt)



APPENDIX 4 SUMMARY RECORD OF NURSERY REARING

Batch no.	1	2	3	4	6	7	8		9	
Duration	20/10-10/12/86	23/1-24/4/87	24/6-4/10/87	16/10/87-5/1/88	5/1-9/3/88	15/2-8/5/88	*9/4-17/7/88*		*28/5-4/9/88*	
	Site 1	Site 1	Site 1	Site 1	Site 1	Site 1	Site 1	Site 2	Site 1	Site 2
30 P happas										
stocked	10,000	28,000	25,000	10,000	15,000	30,000	30,000		30,000	
recovered	ma.	na.	na.	n.a.	n.a.	n.a.	n.a.		x	
16 P happas										
stocked	n.a.	n.a.	n.a.	na.	n.a.	n.a.	na.		Y2 x	Y2 x
recovered	n.a.	n.a.	22,965	5,741	13,927	24,200	20,790		13,352	na.
8 P happas										
stocked	n.a.	n.a.	22,965	5,741	13,927	24,200	10,395	10,345	13,352	na.
recovered	5,000	12,255	20,800	5,029	10,824	24,087	9,925	a	12,277	b
	(50%)	(44%)	(85%)	(50%)	(72%)	(80%)				

REMARKS

n.a. = data not available

At site 2 batches 8 & 9 were not kept separate

a + b = 21,350

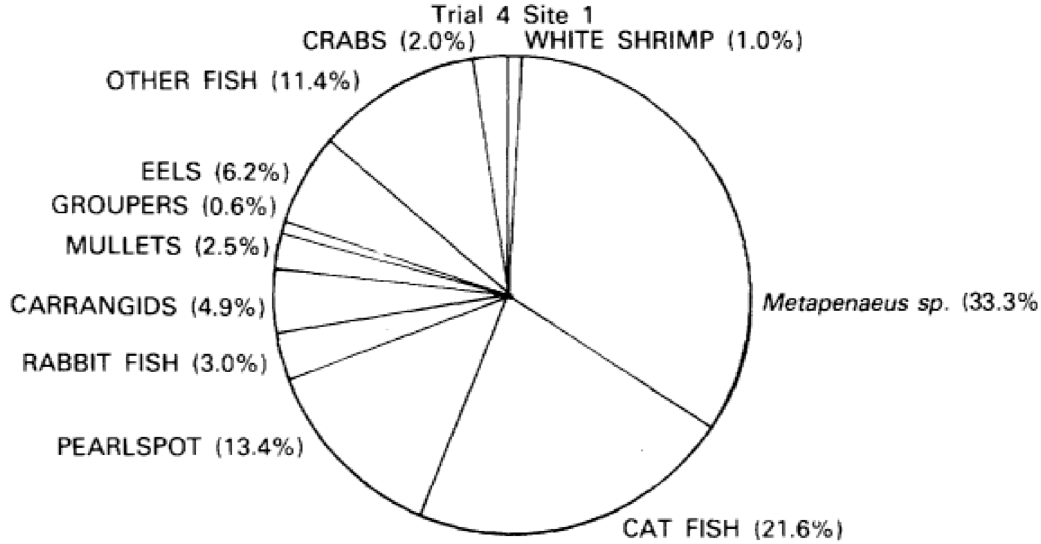
APPENDIX 5 SUMMARY OF PRODUCTION RESULTS

	TRIAL 1 (2/12/86-10/3/87)		TRIAL 2 (27/3-3/8/87)		TRIAL 3 (9/9-4/12/87)		TRIAL 4 (5/1/88-31/12/88)		
	PEN 1	PEN 2	PEN 1	PEN 2	PEN 1	PEN 2	PEN 1	PEN 2	SDO 1 & 2 From 10.4.88
Seeds stocked									
(nb)	5,000	Not stocked	5,000	7,199	12,187	8,662	28,400	22,000	33,100
(Rs.)	5,000		5,000	7,200	12,200	8,700	28,400	22,000	33,100
Feed given									
(kg)	233	–	262	314	205	161.1	978	710	762
(Rs)	6,000		6,600	7,900	5,200	4,100	24,500	17,800	19,100
Harvest									
– Tiger prawn									
kg	8.2	–	58.1	129.5	47.1	50.4	190.3	80.7	85.1
nb	296	–	2,247	4,598	3,630	4,103	11,164	3,533	3,727
– Metapenaeids									
(kg)	na.	–	4.8.2	25.5	1.2	1.6	96.9	40.9	65.6
Fish (kg)	n.a.	–	2&7	47.9	na.	n.a.	148.8	114.9	89.2
– Others (kg)	n.a.	–	4.9	3.8	15.1	18.3	5.8	7.0	10.1
Income generated (SLRs)	1,422	–	11,316.75	25,249.75	6,138.75	6,198	26,241.9	12,863.15	11,168.1

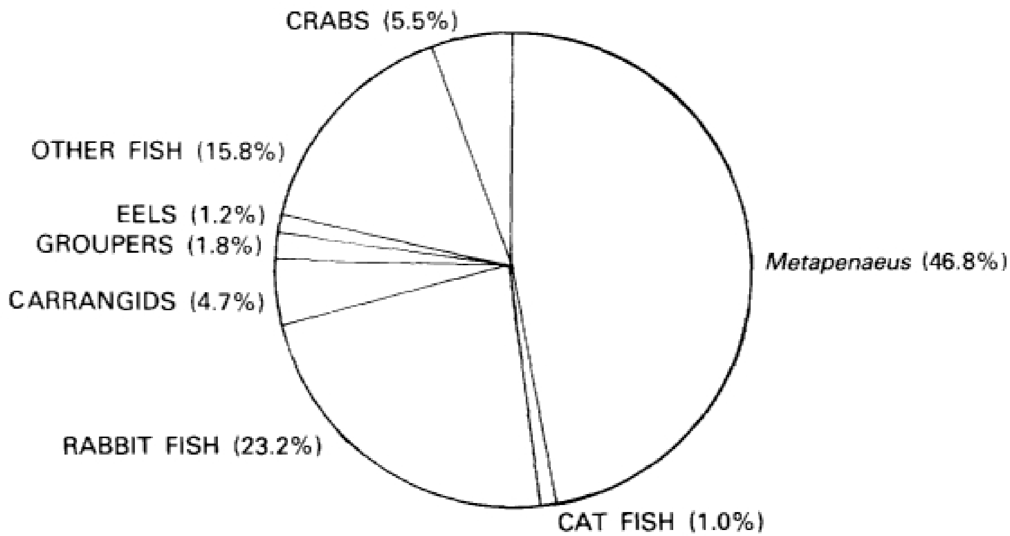
Appendix 6

BY-CATCH COMPOSITION FROM THE PENS

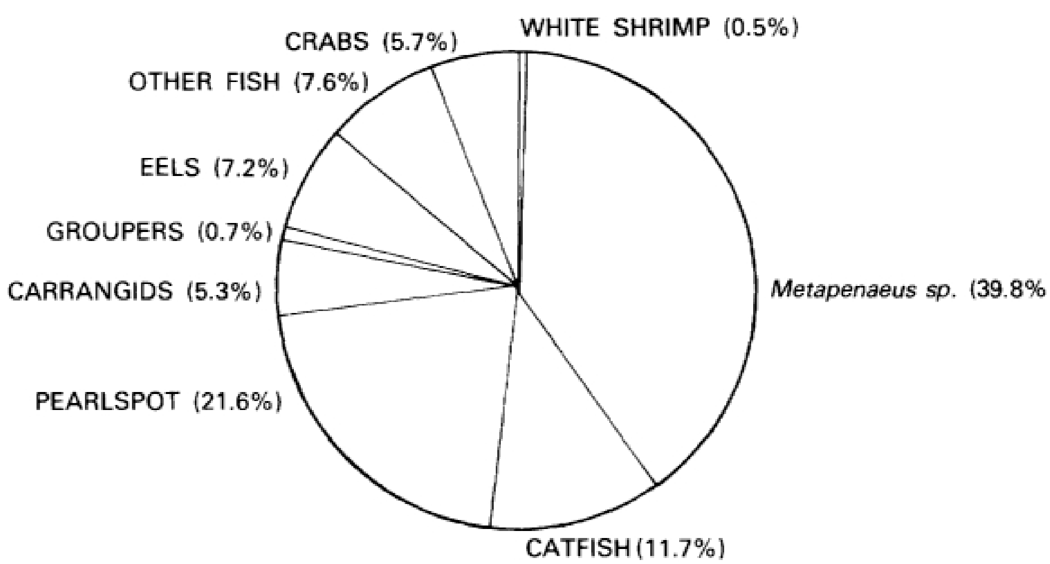
Trial 4 Site 1



Trial 2 Site 1



Trial 4 Site 2



Publications of the Bay of Bengal Programme (BOBP)

The BOBP brings Out six types of publications.

Reports IBOBP/REP/.. .) describe and analyze completed activities such as seminars, annual meetings of BOBP's Advisory Committee, and projects in member-countries for which BOBP inputs have ended.

Working Papers (BOBP/WP/.. .) are progress reports that discuss the findings of ongoing BOBP work.

Manuals and Guides IBOBP/MAG/. .1 are instructional documents for specific audiences.

Miscelleneous Papers IBOBP/MIS/. .1 concern work not originated by BOBP — but which is relevant to the Programme's objectives.

Information Documents)BOBP/INF/. . .1 are bibliographies and descriptive documents on the fisheries member-countries in the region.

Newsletters (Bay of Bengal News), issued quarterly, contain illustrated articles and features in non-technical style on BOBP work and related subjects.

A list of available publications follows.
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